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DOI:
10.1016/j.cpa.2019.04.004

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Document Version
Publisher's PDF, also known as Version of record

Citation for published version (Harvard):
Bebbington, J, Schneider, T, Stevenson, L & Fox, A 2020, 'Fossil fuel reserves and resources reporting and unburnable carbon: investigating conflicting accounts', *Critical Perspectives on Accounting*, vol. 66, 102083. https://doi.org/10.1016/j.cpa.2019.04.004

Link to publication on Research at Birmingham portal

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Download date: 05. May. 2023

Critical Perspectives on Accounting 66 (2020) 102083

Contents lists available at ScienceDirect

Critical Perspectives on Accounting

journal homepage: www.elsevier.com/locate/cpa

Fossil fuel reserves and resources reporting and unburnable carbon: Investigating conflicting accounts

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ARTICLE INFO

Article history:
Received 23 February 2018
Revised 15 March 2019
Accepted 16 April 2019
Available online 3 May 2019

Keywords:
Accounting regulation
Global climate change
Unburnable carbon
Stranded assets

ABSTRACT

This paper investigates fossil fuel reserves and resources disclosures and how they might change in response to global climate change agreements that seek to limit greenhouse gas emissions. On the one hand, it might be expected that fossil fuel firms will be less valuable if their reserves become 'unburnable'. On the other hand, capital markets currently assign a positive value to fossil fuel reserves and resources. A conundrum, therefore, exists. Given that accounting disclosure rules underpin capital market valuation processes, this setting provides an opportunity to interrogate the functionality of accounting during a time of change. To achieve this goal, a multi-methods investigation has been undertaken; combining a survey of accounting disclosure rules for reserves, identification of accounting disclosures made by fuel firms in several country stock markets, and stock market participants' views on the extent to which unburnable carbon exists. Using Miller and Power (2013) we identify when and how unburnable carbon could be recognized in corporate reporting.

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1. Introduction

This paper draws on a body of work that examines the constitutive effects of accounting (Arrington & Francis, 1993; Burchell, Clubb, & Hopwood, 1985; Hopwood & Miller, 1994; Robson, 1992); how accounting practices change over time (Chapman, Cooper, & Miller, 2009; Neimark, 1992; Robson, 1991); and the processes by which change arises (Willmott, Puxty, Robson, Cooper, & Lowe, 1992; Canning & O'Dwyer, 2013). Synthesizing this extensive line of inquiry, Miller and Power (2013, p. 557) suggest that a constructivist reading of accounting[2] highlights the "mutually constitutive nature of accounting, organizing and economizing" and describe accounting as having four functions, namely: (1) (re)creating calculative spaces for organizational and societal actors (territorializing); (2) making it possible for these actors to interact with each other (mediating); (3) providing information that would allow activities to be evaluated (adjudicating); and (4) thereby creating contexts in which control can be achieved (subjectivizing). They suggest that the "entanglement of these

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[1] Formerly.
[2] We have taken this characterization of accounting to include disclosures in documents such as the annual report and accounts.

https://doi.org/10.1016/j.cpa.2019.04.004
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four roles … gives the "accounting complex" its productive forces, such that it is perhaps the most powerful system of representation for social and economic life today" (Miller & Power, 2013: 558).

The empirical focus for this paper is the extent to which accounting and reporting representations reflect global climate change concerns. Specifically, an apparent contradiction is emerging between representations of the value of fossil fuel reserves: in Miller and Power's (2013) terms, two sources of territorializing practices. On the one hand, data in annual reports and accounts quantify fossil fuel reserves and resources, and financial markets ascribe value to reserves and resources because they imply a future revenue stream. In contrast, global climate change science (alongside regulatory regimes in this area) suggests that not all fossil fuel reserves and resources currently identified will be combusted because to do so would lead to greenhouse gas emissions targets not being met (hence the phrase 'unburnable carbon'). Further, it is argued that the financial value of reserves and resources would be materially affected if the environmentally infused view of the value were to be the 'better' descriptor of 'reality'. The first aim of this paper, therefore, is to explain why these contrasting and mutually exclusive accounts of the value co-exist and to identify under what conditions we might expect to see changes in the value of fossil fuel firms. To achieve this aim, we have undertaken interviews with market participants; a survey of required disclosure practices and a survey of corporate reporting to document and explain an absence of disclosure. At the same time, this setting creates the opportunity to support the second aim of the paper: to understand the functionality of accounting where there has yet to be a process that mediates between worldviews (using the language of Miller & Power). The Miller and Power (2013) framework has been developed to narrate broad developments in accounting scholarship: in this analysis we seek to understand its functionality in the context of a specific accounting problem.

The suggestion that there may be unburnable carbon on the stock market was developed and championed by an NGO actor (the Carbon Tracker Initiative – see Carbon Tracker Initiative, 2011, and http://www.carbontracker.org/) and informed (and continues to inform) a fossil fuel divestment campaign (see http://gofossilfree.org/uk/; Ritchie & Dowlatabadi, 2015; Ayling & Gunningham, 2017). Further, and using the language of capital markets risk, the Carbon Tracker Initiative proposes that a 'carbon bubble' may form on stock exchanges if valuation tensions are not resolved. The issue of unburnable carbon has caught the attention of the United Kingdom Financial Stability Board (Batten, Sowerbutts, & Tanaka, 2016) as well as the Governor of the Bank of England (Carney, 2015), albeit that these bodies do not currently believe that there is a carbon bubble forming on the UK Stock Exchange.

Accounting disclosures are critical to the effective functioning of stock markets. In Miller and Power's (2013) terms disclosure is essential to adjudication and information provision will allow evaluation of activities. We explicitly argue (in Section 2 and elsewhere in the paper, informed by science and policy literature) that we ***should*** see disclosures about the issue of unburnable carbon. In so doing, the paper engages with the longstanding issue of when accounting "inscriptions … [are] recognisable to their users" (Robson, 1992, p. 695) and what happens when these representations are called into question. Indeed, this is why the Carbon Tracker Initiative has focused attention on accounting rules (Association of Chartered Certified Accountants & Carbon Tracker Initiative, 2013; Carbon Tracker Initiative & the Grantham Research Institute, 2013) which they believed would provide a point of connection between global climate change concerns informed by science and policy, and inscriptions of economic value ascribed to fossil fuel companies by capital markets. This ambition meshes with Miller and Power's (2013) concept of territorializing. What will become apparent from our data analysis, however, is that territorialization has not been achieved despite accounting valuation and disclosure rules being in place to support disclosure if carbon is judged to be unburnable. Why this might be the case and the implications that arise as a result are developed from this evidence base.

The paper will proceed in the following manner. Section 2 explores the unburnable carbon proposition, drawing from policy and academic literature in order to set the scene for the paper. Given that scientific understanding may develop separately from capital market considerations, Section 3 presents findings from interviews with a number of capital market participants. Their views shed light on how and when the territorializing, mediating, adjudicating and subjectivizing role of accounting might be observed. Analysis then moves to focus specifically on adjudication by examining disclosures that have been made about unburnable carbon. In order to conduct this analysis, the recognition, measurement and reporting requirements for fossil fuel reserves and resources are reviewed in Section 4 (including technical measurement standards, financial reporting requirements and stock exchange listing disclosure requirements and recommendations). As will become apparent from this review, fossil fuel reserve and resource disclosure is itself an 'unsettled' practice which reflects longstanding political and economic contingencies (aligned with the economic consequences of accounting standard setting literature – see Cortese, Irvine, & Kaidonis, 2009).

The paper then moves to present the disclosures of a sample of fossil fuel companies listed in seven countries, namely: Australia, Canada, China, Russia, South Africa, the United Kingdom and the United States of America. These countries have been selected for analysis as each of them have substantive listings of fossil fuel companies on their stock exchanges, and hence if we are to detect early stages of unburnable carbon disclosures it will likely be on these exchanges (likewise any bubble will affect these exchanges disproportionately). Disclosures are documented for sample companies across several reporting formats including: statutory disclosure formats (such as Annual Reports and Accounts; Forms 20F and/or Forms 10-K); in returns made to the Carbon Disclosure Project (a private investor lead global climate change information governance initiative, now known as CDP – https://www.cdp.net/en) and in standalone reports. Two time-periods were sampled for the main analysis (2011 and 2014) to provide snapshots of evolving disclosure patterns. Subsequent to this analysis, Section 5 of the paper seeks to explain the pattern of accounting related disclosure in the face of the unburnable

carbon proposition. Finally, in Section 6 concluding comments are made with respect to what this empirical study might suggest about the nature of accounting, returning to the characteristics outlined by Miller and Power (2013) and seeking to extend our observations beyond the specifics examined in the paper.

2. Making the case for unburnable carbon

There is widespread scientific consensus that anthropogenic global climate change is happening and, if left unchecked, will have a significant negative impact on human and non-human populations (Intergovernmental Panel on Climate Change, 2007, 2014; Department of Energy and Climate Change, 2011; Stern, 2006; United Nations Framework Convention on Climate Change, 2015). A desire to avoid this outcome has resulted in the development of a variety of initiatives, including international agreements (of which the Paris Agreement is the most recent and wide ranging)[3] and regional responses (such as the European Union Emissions Trading Scheme) through to national laws.[4] All these initiatives (with different degrees of enforcement mechanisms) seek to mitigate global climate change by reducing emissions, primarily by focusing on reductions in fossil fuel combustion (that is, reducing oil, gas and coal use). A central concept in this area is that of a carbon budget. This is a physical measure of how much greenhouse gas can be emitted in a given time period, for a defined set of activities or for a particular territory/population, if emission targets are to be achieved. The most usual target in science and policy is the desire to keep global average temperature increase below 2 degrees Celsius, as it is believed that beyond this point there is a tipping point in the climate system that will be detrimental to human flourishing (in 2018 a IPCC special report recommended lowering this aim to 1.5 degrees of warming – see https://www.ipcc.ch/sr15/about/history/). A carbon budget also implies that there are carbon emissions that should not be generated; in the context of fossil fuel reserves in the ground, that there is carbon that is unburnable if climate change goals are to be met. Critically for this paper, Jakob and Hilaire (2015, p. 150) estimate that cumulative emissions must be less that "870–1240 giga-tonnes between 2011 and 2050 ... [and that] the carbon contained in global resources of fossil fuels is estimated to be equivalent to about 11,000 Gt of CO_2, which means that the implementation of ambitious climate policies would lead to large proportions of reserves remaining unexploited".

Past economic development has relied upon fossil fuel energy, with that energy being available at relatively low prices. In the early 2000s, there were signs that the time of cheap fossil fuels were over (Kjärstad & Johnsson, 2009). However, coal remains an abundant resource and the recent rise of non-conventional oil and gas implies that an era of 'peak' oil is not imminent (McGlade & Ekins, 2015). For the next century or so it appears that the main factor limiting the use of fossil fuels will be the collective efforts of the international community to transition to a low carbon economy. Such a transition is likely to change the value of fossil fuels, albeit that this change is not currently apparent. For example, while national and international policies are being developed and implemented to meet 2020 and 2050 targets, nations are simultaneously encouraging the development of non-conventional fossil fuel resources, often subsidising these activities alongside conventional fossil fuels. In addition, there are considerable vested interests involved in terms of the timing of any low carbon transition, in which regions/countries reductions will first be seen, and which sectors will transition first (for example, energy production versus transportation). As a result, while global climate change governance regimes focus on limiting emissions, the detailed reduction trajectory (and whose carbon will be reduced first) is not fully determined. This makes it hard to know when, where and to what degree fossil fuel firms might face carbon constraints.

What is clear, however, is that in the longer term some form of restriction will emerge. Two papers highlighted this restriction in *Nature*, leading to the first public realization that there may be an issue in this context (Allen et al., 2009; Meinshausen et al., 2009) with their propositions being reinforced, with increasing layers of granularity, over time. For example, the International Energy Agency, estimates that only two thirds of existing proven fossil fuels reserves (see Section 3 – this terminology has specific meaning) can be burned if the objective of a 2 °C increase in temperature by 2050 is to be achieved (International Energy Agency, 2012, p. 98). In a similar vein, McGlade and Ekins (2015, p. 187) examine limits by fossil fuel type and region and "suggest that, globally, a third of oil reserves, half of gas reserves and over 80 per cent of current coal reserves should remain unused from 2010 to 2050 in order to meet the target of 2 °C". With this background in mind, the opening element addressed in this paper is how capital market participants understand the divergence between global climate change policy, the valuation of fossil fuel companies and the plausibility of unburnable carbon being found on stock markets. In Miller and Power's (2013) terms, the interviews focus on the process of adjudication: that is, the provision of information for evaluation. Both territorialization and mediation are precursors to such a process. The interviewees' views will be presented alongside a literature review on the same topic.

[3] The political stability of the Paris Agreement is not guaranteed. Indeed, the USA has signaled its intention to withdraw from the Agreement (a view not shared by many of the States and cities within the country – see Bebbington & Harrison, 2017). Regardless of the position of any particular United States administration, the issues addressed in this paper remain pertinent. It is also the case that the government of the United States is not the only one to show myopia when it comes to climate change and future industry strategy: Lucas (2016) examines the risk of stranded assets in the Australian coal industry.

[4] See Nachmany, Fankhauser, Setzer, and Averchenkova (2017) for the most current legislative update and http://www.lse.ac.uk/GranthamInstitute/research-theme/governance-and-legislation/ for a searchable database of legislation.

3. Making sense of unburnable carbon – expert interviews and related literature

This section reports on 14 expert interviews with individuals who might be expected to have a view as to the plausibility of the unburnable carbon proposition. 12 of the interviews were conducted between February and April 2012 (when the unburnable carbon story was newly circulating in the media) with the other two being conducted in 2014 to gain insight on how experts were considering unburnable carbon at this later time. Individuals were located in Canada, the United Kingdom and the United States of America and included individuals who worked for carbon reporting institutions; financial accounting institutions; investors and their representative bodies; banks; fossil fuel companies and their industry associations; security regulators and academics. Ethical approval was obtained for this work and the usual protocols were followed to ensure informed consent was given, the right to withdraw from the work was guaranteed as was anonymity. The potential interviewee list and the questions to be asked were developed in consultation with the Carbon Tracker Initiative and was informed by their central role in this debate. A summary of interviewee characteristics is presented in Table 1.

Some further observations about the interviews is necessary. A larger number of individuals ($n = 43$) were approached for an interview by name (and not through a general contact to an institution). Some responded but declined to be interviewed with the reason that they viewed unburnable carbon to be a politically sensitive issue that they did not feel happy to engage with. The larger number of our potential interview list, however, never responded to our initial and follow up requests for a conversation. Moreover, a number of those who did consent to speak with us wished to stress they were speaking in their personal (rather than their professional) capacity. The majority of interviewees were reluctant for the conversations to be taped so notes were made after interviews. For four of the 14 interviews email correspondence was used to elicit answers to the questions. The interviews were semi-structured around three broad themes: (i) how tight future carbon constraints are likely to be, (ii) the plausibility of the idea of unburnable carbon, and (iii) what implications would arise if there is unburnable carbon on stock exchanges.

Our initial desire to construct a full interview series of some 30+ people to 'test' degrees of agreement/disagreement with the idea of unburnable carbon, therefore, was not possible. It is almost certainly the case that the interviewees we spoke to are biased because they were individuals who were prepared to express a view on unburnable carbon. While they, in general, saw the rationale for there being unburnable carbon, they also sought to explain why they believe others might resist that notion. Given these constraints, we have used the interviews to structure themes around which explore the issue at hand. Specifically, an inductive thematic analysis of the 2012 interviews was undertaken (at that time little was known about how and when territorialization might take place: that is, when carbon constraints might be reflected in capital markets). Using these themes, a wider search for literature on the topics discussed was subsequently conducted in order to better understand the points being made and also to place these views in the context of insights that continue to emerge. This approach was also adopted to counter the paucity of interview data and to establish if there is wider support for their views. As a result, this section threads together interview responses with observations that can be found in the literature in order to develop a fuller narrative about the topics of interest. This is not the 'usual' function of an interview series in research. Rather, it is an approach that enables the insights offered by these experts to enhance our analysis of firm disclosure and inform our theoretical framework focused on Miller and Power (2013).

Accurate determination of quantities of fossil fuel reserves and resources across the globe are not straightforward (see Grubert, 2012; Kjärstad and Johnsson, 2009; Owen, Oliver, Inderwildi, & King, 2010) with the price of fossil fuels on global markets significantly affecting reported quantities of commercially recoverable reserves. Regardless, evidence exists that should we wish to combust fossil fuels (and are willing to pay to do so) there is no lack of underlying resource. What is also clear, is that measures "to comply with CO_2 emission targets as recommended by the Intergovernmental Panel on Climate Change will have a profound impact on future demand for oil" (Kjärstad & Johnsson, 2009, p. 445).

McGlade and Ekins (2015) address this issue directly and provide a breakdown of unburnable carbon by fossil fuel type and region. First, McGlade and Ekins (2015, p. 187) reiterate that emissions "contained in present estimates of global fossil fuel reserves are around three times higher" than that which could be combusted if the 2 °C target is adhered to and note that this would have "profound implications for the future utilization of oil, gas and coal" (McGlade & Ekins, 2015, p. 188). The article (using an assessment model – itself "subject to wide bands of uncertainty", McGlade & Ekins, 2015, p. 188) estimates quantities of known reserves that should not be combusted and suggests what the regional distribution of unburnable carbon might be (this will be further discussed later). While this work was published three years after the bulk of the interviews were conducted for this paper, interviewees demonstrate appreciation of these principles ahead of that empirical analysis.

Interviewees all agreed that it is logical that climate change governance will create (at some point in the future) a limit on the amount of greenhouse gas that can be emitted and that this level is below current emissions. Further, interviewees believed that when a constraint crystalizes, the valuation of fossil fuel firms would be materially affected.[5] The question raised by all interviewees, however, was "when will the regulatory environment move to the point of constraint?" (banker). One academic interviewee believed that: "it all rests on domestic and international regulation of carbon and the coming

[5] This accords with Griffin, Jaffe, Lont, and Dominguez-Faus (2015, p. 2) who state that "unburnable fossil reserves places at risk some 40% to 60% of the market capitalization of the world's top 200 energy companies".

Table 1
Interviewee summary.

Interviewee background/expertise	Details (number interviewed; year of interview; location of interviewees and geographic location*)
Academics	Two interviewees; conducted in 2012; UK based
Banks	Two interviewees; conducted in 2012; mainland Europe based
Carbon reporting institutions	One interviewee; conducted in 2012; UK based
Financial accounting institutions	One interviewee; conducted in 2012; UK based
Government agencies	One interviewee; conducted in 2014, Canada based
Investors and representative bodies	Five interviewees; conducted in 2012; UK and USA based
Securities regulators/stock exchange	Two Interviewees; conducted in 2012 and 2014; Canada and UK based/

* While these interviewees were based in a particular location, all of them had an international focus on the issues at stake and several of their organisations had an international remit.

together … [of various elements] to form an international framework". Another interviewee (stock exchange) suggested that by 2020 the UK's carbon budgets might be sufficiently tight so as to alert capital markets to carbon constraints (another academic interviewee believed that by then international negotiations would have brought about a global governance regime). Taken as a whole, therefore, interviewees had a common belief that at some stage (most likely in the medium term) carbon constraints will become pressing which would ultimately have an impact on firm valuations and that these changes will have an effect on stock markets. In Miller and Power's (2013) terms they could see a time when processes of territorialization and mediation would result in adjudication. The direction of such an effect, however, was not seen as being straightforwardly predictable.

While one might expect an emission constraint to decrease firm value (due to an inability to utilize a resource under their control) interviewees expressed uncertainty about this expectation. One (academic) interviewee suggested that: "if climate policy puts in place restrictions … [on] the use of fossil fuels then valuations will plummet (with policy driving innovation around alternative sources of fuel in the short term). If restrictions are brought in over time and roughly match known reserves, then the fossil fuels (in particular oil) could be seen as a scarce resource … [increasing] the price of oil and … oil companies". This view was also shared by another interviewee (investor) who believed that gas reserves would become more valuable in a carbon constrained world and hence (depending on type of fossil fuel held) individual firm valuations might not fall even if overall fossil fuel sector values do reduce (see also Wolf, 2012). Before the event, what the process of adjudication would generate was, therefore, uncertain.

These interviewee views reflect subsequent literature. For example, Van de Graff and Verbruggen (2015) also contest the assumption of a falling value of fossil fuels, noting that how climate policy is implemented (for example, through taxes versus efficiency standards and renewable subsidies) will have different price effects on fossil fuels. Another point was made by an analyst (quoted in Crooks, 2016) who "calculated that about 80 per cent of the market capitalisation of the large international oil companies reflects their proved reserves, which they expect to produce over the next 10–15 years" – well ahead of any hard constraint coming into play.

Some interviewees had other grounds on which they argued against seeing a financial market effect of carbon constraints, namely: (i) the relative size of listed versus state owned fossil fuel companies may dampen out any stock market effect, and (ii) that technologies (such as carbon capture and storage) will mean that governance induced constraints might be delayed. Each of these issues with respect to how territorialization could be achieved is now explored in more depth.

One interviewee (an investor) claimed that given listed companies hold only 5% of global reserves (with state owned companies holding the largest share) any misreporting of reserves for these firms might not have a material impact on stock markets (see Ritchie & Dowlatabadi, 2015; Mitchell & Mitchell, 2014). Kjarstad and Jonsson (2009) also noted the relatively larger size of national oil companies (as compared to those listed on stock exchanges and pointed out that while the six major oil companies owned 4% of global reserves in 2006 they accounted for 14% of global production (see also CDP, 2016, who track historical cumulative emissions and estimate that state owned fossil fuel firms account for 59% of cumulative emissions). Another (academic) interviewee agreed that the balance between listed and non-listed firms was a valid consideration but noted that, if global carbon constraints are agreed, all firms (listed or otherwise) will be affected, and that this would affect the market for fossil fuels (with knock on effects on firm valuation and stock markets themselves). In this respect, the impact of a constraint would depend on the nature of a particular country, with some facing political unrest or economic turbulence as constraints bite (see Van der Ploeg, 2016, for a series of possible scenarios). As a result, political uncertainty might create risks for all companies (some of which would be listed) operating in the country and these risks would be translated to stock markets substituting political risk for regulatory risk.

The second area of debate reflected a belief that some form of new technological change (for example, carbon capture and storage) will ensure that business as usual will be possible. Again, interviewee views were supported by subsequent analysis. For example, (McGlade & Ekins, 2015, p. 188), note that "the availability of carbon capture and storage has the largest effect on cumulative production levels" (while Van de Graaf & Verbruggen, 2015, p. 458 describe carbon capture and storage as "fraught with huge uncertainty, technically, economically and politically"). This type of thinking is reflected in Griffin et al. (2015, p. 3) who suggested "while unburnable carbon may be a compelling story with worrisome implications for many, rational investors, would 'see through' the metaphor and analyze … strategic options". While, technological innovation might mean that carbon constraints will not be faced as quickly as they may otherwise be, a precautionary

approach would suggest that this is not a reason to ignore them. Moreover, Vergragt, Markusson, and Karlssonm (2011, p. 282) are representative of those who have concerns that while carbon capture and storage is a possible 'bridge' technology (that is, it might buy time for a low carbon transition) it might also lead to a "reinforced fossil fuel lock-in" which would not be helpful in the longer term.

As is evident from the above discussion, uncertainty as to when and how any constraint might evidence itself exists. It would seem, however, from a review of the literature in this area (as well as the views of the majority of interviewees), that there is value in considering the likely impact of global governance driven constraints on the ability of fossil fuels to be combusted. Logically, any constraint will have a knock on effect on the valuation of fossil fuel firms and on stock markets more broadly. The impact of any constraint relies on the ability of the market to identify, understand and react to it. Whether or not the market is likely to do this, and what might need to change for this to be the case, was also discussed in the interviews.

Interviewees suggested that stock market carbon literacy is essential for subjectivization (that is, to create a context where control can be achieved). There were also different views as to how carbon-literate stock markets are. One group (the smaller) suggested that if the risk of global climate change is significant, then the market would have already by definition factored it into their models and if they have not done so, then the information is irrelevant. Leaving aside the tautological nature of this argument, this view reflects a faith in the ability of markets to be well enough informed on matters of global climate change to be able to evaluate and incorporate risks into firm valuation, as well as there being information that would allow this to happen (a point we examine in section four). The majority of the interviewees, however, did not share this view. Indeed, one stock exchange interviewee suggested that markets "will wake up, but will wake up late" and that the reason for this is that "physical factors are completely outside of analysts' frames of reference ... they don't see the relevance of these factors and only see the relevance of market factors". Regardless of carbon literacy, a clearer understanding of how valuations are made is also relevant, and here existing literature adds insight to interviewee propositions.

Standard methods of valuation in the oil and gas sector rely on a combination of expected prices, costs and reserves volumes (Johnston & Johnston, 2006). Current reserve reporting provides estimates of these three items, either separately or in combination (that is, net present-value calculations). The calculation of volumes is well-defined and relatively precise, particularly in aggregate, where the law of large numbers takes effect. How these volumes are affected by prices and costs is more ambiguous and difficult to forecast. Medium to long-term concern over carbon constraints might fit into specific investors' (and non-investors') valuations in different ways. For example, Cormier and Magnan (2002) note that a number of uncertainties affect fossil fuel valuations including the underlying volatility in resource prices (such as oil and gas). In addition, these authors note that there is "extensive discretion ... in the recognition and measurement of reported earnings" (Cormier & Magnan, 2002, p. 132) which further complicates firm valuation (see also Luther, 1996), with accounting choices in this area having well documented economic consequences (Cortese et al., 2009).

Focusing specifically on reserves disclosure, Cormier and Magnan (2002) also explored how data on reserves discoveries, extensions and acquisitions affected firm valuations and found that this information possessed "incremental information content in explaining a firm's stock market value ... [and are] positively associated with a firm's stock price" (Cormier & Magnan, 2002: 145 – a finding consistent with Spear, 1994, 1996; Teall, 1992). What is less understood is the relative role of reserves data in valuations and the stability of this influence over time. Harris and Ohlson (1987) provide evidence that book-value is more value-relevant than the reported present-value of reserves under U.S. GAAP. They provide two possible explanations for this result. The first is that historical costs reflect what a firm has paid for its oil and gas properties and that effectively 'you get what you paid for'. This implies a rational explanation, whereby the historical costs of exploration, development and acquisition of reserves reflect a reasonable approximation of the market value of reserves. However, Harris and Ohlson (1987) also suggest that their results might imply a functional fixation with the accounting numbers and an inability of the market to incorporate other information into prices. This would imply that until carbon constraints are directly reflected in transactions and costs (a process of territorializing), they will not be reflected in stock prices.

This is not to say that information about carbon constraints has never translated to stock prices. In a test of the impact of the *Nature* papers discussed in the introduction, Griffin et al. (2015) found a small negative stock price drop (for a sample of the 63 largest U.S. oil and gas firms) subsequent to media coverage of these articles suggesting, in their analysis, "results consistent with the rational response hypothesis, namely, that despite the relative obscurity of the *Nature* article, stock prices declines by 1.5–2.0% ... over days −1 to 1 around the ... publication date" (p. 9). Later (in 2012/13) more press stories emerged on the idea of unburnable carbon but these had no statistically significant impact. These authors also note the general tension our interview series exposed: that "evidence does not support the predictions of many that recognition of unburnable carbon might prompt a substantial reduction in the shareholder value of fossil fuel firms" (Griffin et al., 2015, p. 9) while also noting that they could not "rule out the possibility of a carbon bubble ... as market prices in the past have grossly deviated from the underlying fundamentals" (Griffin et al., 2015, p. 10).

Another reason for a lack of effect may be that investors do not know which carbon will become unburnable. This suggestion finds some support in, for example, Busch and Hoffmann (2007, p. 522) who identify an event where a potential future global climate change related cost was reflected in the capital market. Busch and Hoffmann (2007) noted that "Xstrata, a FTSE 100 listed company that exports coal to Japan ... [shares] fell approximately 10% in just a few days" after an announcement by the Japanese Government that it was considering a coal levy. It might be that in this case the

effect was observed because of the ability to link a restriction to a particular firm and fossil fuel type in a specific location. Indeed, they suggest that individual firm effects of a general constraint will depend on "a wide range of different factors such as emission-intensity, energy source mix, geographical location of production facilities, marginal abatement costs and technology trajectory" (Busch & Hoffmann, 2007, p. 524). This strongly suggests that information disclosure will need to be sufficiently detailed to enable nuanced modeling of firm specific effects. Indeed, McGlade and Ekins' (2015, p. 189) estimation of unburnable carbon (by location and fossil fuel type) yields large ranges of estimates. For example, in the USA they estimate 6% of oil; 4% of gas and 92% of coal is unburnable while in Canada the figures are 74% of oil; 24% of gas and 75% of coal. Obviously, these differences will generate unequal exposure to unburnable carbon and would require more detailed corporate disclosure than is currently provided.

A combination of evidence drawn from expert interviewees and the literature, therefore, suggests that global climate change governance will create constraints that will be value relevant and potentially material. It also seems to be the case that markets are able to respond to climate change governance impacts and hence could be assumed to react (if it was necessary) to re-value fossil fuel stocks. Interviewees were aware of the complexity of developing a coherent approach to ensuring that any carbon constraints (and their timing) are properly determined and expressed in ways that would allow market participants to translate this information into firm specific risk assessments and valuation decisions and from there to achieve adjudication and subjectivization. Complexity in this area arises from the inherent uncertainty in the phenomena being considered (that is, the existence and impact of constraints) as well as the difficulties associated with providing disclosure in this area. For example, one interviewee (banker) suggested that the provision of information from a trusted source on country level risk exposure as well as sector associations making information available on risks by fossil fuel type would be helpful (echoing data that has subsequently been developed by McGlade & Ekins, 2015). The interviewee noted that self-interest might make the provision of this information unlikely, but that it would be a precursor to understanding any data that might be provided by individual firms. Likewise, the willingness of firms to disclose data that might highlight risks was questioned; it is in this area that the issue of regulation of data was raised.

One interviewee (carbon reporting body) noted that disclosure of greenhouse gas emissions had developed quickly with the establishment of the CDP and the Climate Disclosure Standards Board and that these bodies might facilitate the process of determining what 'good' quality disclosure in this area would look like (see, for example, CDP, 2016). Likewise, movements in the development of integrated reporting were viewed by one investor as being synergistic with reporting needs in this area. Indeed, one investor interviewee noted that Chairmen (sic) were starting to consider the strategic impact of the global climate change agenda and this might eventually translate into disclosure (but that presently it had not done so, due to perceived investor indifference). Other interviewees appeared more interested in mandatory disclosure, with stock exchange listing requirements being identified as a mechanism for disclosure. Indeed, one investor described stock exchange listing bodies as being the "gatekeepers to international sources of finance" and suggested that if they required information then it would be provided. While this might be the case, stock exchange listing bodies might not be willing to increase data requirements in response to every issue that stakeholders think is desirable (and, indeed, existing disclosure requirements might be sufficient for these purposes – see Section 4).

In summary, interviews with market participants alongside a review of the relevant literature suggests that the principle of unburnable carbon is conceptually sound. What is less accepted is when carbon might become unburnable and the impact of this on company valuation. These are matters that one might expect companies themselves are thinking about – even if they are not discussing the matter in the public domain. There is a need, however, to check if there are any relevant disclosures about unburnable carbon in accounts as well as to consider if there is adequate disclosure requirements to support disclosure. It is to these two questions that our analysis now turns: these are also central questions if the territorializing effect of accounting and reporting are to emerge.

4. Disclosure survey: requirements and sample disclosures

In this section we present an over-view of the predominant disclosure requirements for fossil fuel reserves and resources that companies must follow if they want to be listed on a stock exchange. We then undertake a company-specific survey of disclosures within seven countries that have substantial listings of companies involved in fossil fuel exploration, development and production, seeking evidence about the incidence of disclosures that could be linked to unburnable carbon. The disclosure survey undertaken encompasses two time-periods (2011 and 2014). The earlier time-period was selected as it was immediately after the Carbon Tracker Initiative (2011) publication that sought to make the argument that capital markets should consider unburnable carbon. The countries and companies for the 2011 survey were also selected after consultation with the Carbon Tracker Initiative. This initial analysis identified little disclosure, so a second round of analysis was undertaken in 2014, to see if there had been movement during the intervening years. The countries surveyed were: Australia, Canada, China, Russia, South Africa, the United Kingdom and the United States of America. The media surveyed for this study includes conventional financial reports, alongside disclosures made to the CDP and any standalone reports. Taken together, this sampling strategy is aimed at uncovering any 'leading edge' reporting (more detail of the disclosure capture protocols are contained in Section 4.2).

4.1. Classification, evaluation and reporting of Reserves and Resources

Reporting by mineral and oil and gas companies is regulated by a complex of standards emanating from a number of sources (see also Linnenluecke, Birt, Lyon, & Sidhu, 2015). The determination of the physical quantity of reserves and resources requires three steps: evaluation, classification and disclosure. There are a number of published evaluation and classification systems to support reserves and resource determination (see Camisani-Calzolari, 2004, for a brief history). These do not have regulatory force in and of themselves. Rather, their use is required by other regulatory organisations (for example, the European Securities and Markets Authority or the United States Securities Exchange Commission, hereinafter SEC). The common classification system for minerals is the Committee for Mineral Reserves International Reporting Standards (CRIRSCO, 2013) template. The CRIRSCO template is the set of standard definitions and principles that are incorporated in the family of standards developed under the auspices of the International Council for Mining and Metals, a CEO-led industry group. For oil and gas evaluation and classification, the Petroleum Resource Management System (PRMS) is commonly used, developed by the Society of Petroleum Engineers (2007). In addition to these internationally agreed standards, most countries also specify their own standards for classification and evaluation. All these systems, however, are mapped to the PRMS and CRIRSCO templates (with the main differences between the national and other standards arising in the evaluation methods dictated and the types of disclosures allowed or required). The systems in place for the seven countries surveyed are outlined in Appendix 1.

Fig. 1 outlines the classification system used by PRMS. Production refers to the sum of all volumes produced to date, beyond this category all figures are estimates. The general term 'reserves' typically refers to oil and gas and mineral resources that are commercially viable and are further broken down into the sub-categories of proved (P1), probable (P2) and possible (P3). Contingent resources are those discovered, but not commercially viable because of any one of a number of contingencies and reflect the same profile of probabilities that reserves and prospective resources do in Fig. 1. For conventional oil and gas, the main issue in the past regarding classification was whether the oil could be discovered and if, once discovered, it was technologically feasible to extract the resource. In contrast, unconventional resources have generally been discovered for some time and it was a matter of determining how to extract them (for example, by fracking). It is within these rules that any unburnable carbon could be recognized. Environmental and social considerations are specifically addressed in determining the commercial viability of a reserve under the PRMS. If reserves were deemed to be subject to a combustion constraint, they should be re-classified as contingent resources (that is, contingent on their ability to be utilized).

The PRMS classification system in Fig. 1 is not to scale; if it was, the unrecoverable volumes would be much larger. Most resources will never be produced within any foreseeable future, regardless of any carbon constraints. In this paper, questions around unburnable carbon relate primarily to reserves and these are only a small portion of the oil and gas resources we know about, let alone of the oil and gas that exists somewhere in the lithosphere.

Moving to mining, the CRIRSCO template has analogues to the PRMS system. The CRIRSCO template includes social and environmental aspects in its 'Modifying Factors', where consideration of mining, metallurgical, economic, marketing, legal, *environmental*, social and *governmental* factors are what determine if a measured or inferred resource can be classified as a reserve (our emphasis). The various country specific codes that map to the CRIRSCO template also contain similar language. For example, the Australasian JORC (2004), includes other information that should be considered and disclosed as part of the evaluation process, namely: "[t]he effect, if any, of natural risk, infrastructure, environmental, legal, marketing, social or governmental factors on the likely viability of a project" (JORC, 2004, p. 18). How one might evaluate if these modifying factors are present rests on the skill and competencies of those making these classifications and it is here that these technical standards have parallels to the accounting profession.

Each of the classification and evaluation systems considers the competency of the individual (defined as a 'competent person' under PRMS and CRIRSCO) tasked with the preparation of the reserves and/or resource reports (with some differences between the codes, such as whether or not the evaluator must be a third party). Camisani-Calzolari (2004, p. 204) emphasizes that the competent person "is a fundamental concept in these codes". Of specific interest for our purposes is the extent to which environmental matters are relevant to the work of evaluators. CRIRSCO's reporting template notes that "[c]ompetent persons must discharge their duties with fidelity to the public…[and in] particular…recognise at all times that the responsibility of competent persons towards the public overrides all other specific responsibilities including responsibility to professional, sectional, or private interests" (p. 35). Further, they state "[i]n performing their work, competent persons should strive to protect the natural environment" (p. 36). Competent persons are also required to "[e]nsure that mineral reserve estimates acknowledge the likely environmental impact of development and ensure that appropriate allowances are made for mitigation and remediation" (p. 36). As a result, there are two layers of requirements for environmental matters to be addressed in the classification process. First, all companies falling under a reporting code are required to consider environmental factors in their justification of whether or not reserves can be extracted. Second, the competent person is reminded that considering environmental factors is part of their professional duty to the public.

Along with being subject to the professional skills and integrity of the competent person, evaluations are also subject to corporate governance oversight. Many firms have reserve committees that oversee resource reporting. Any of the senior management sign-offs, such as those required under the U.S. Sarbanes-Oxley Act (2002), also require assurance that the evaluator has followed due diligence. Taken together, therefore, several opportunities for unburnable carbon reserves to

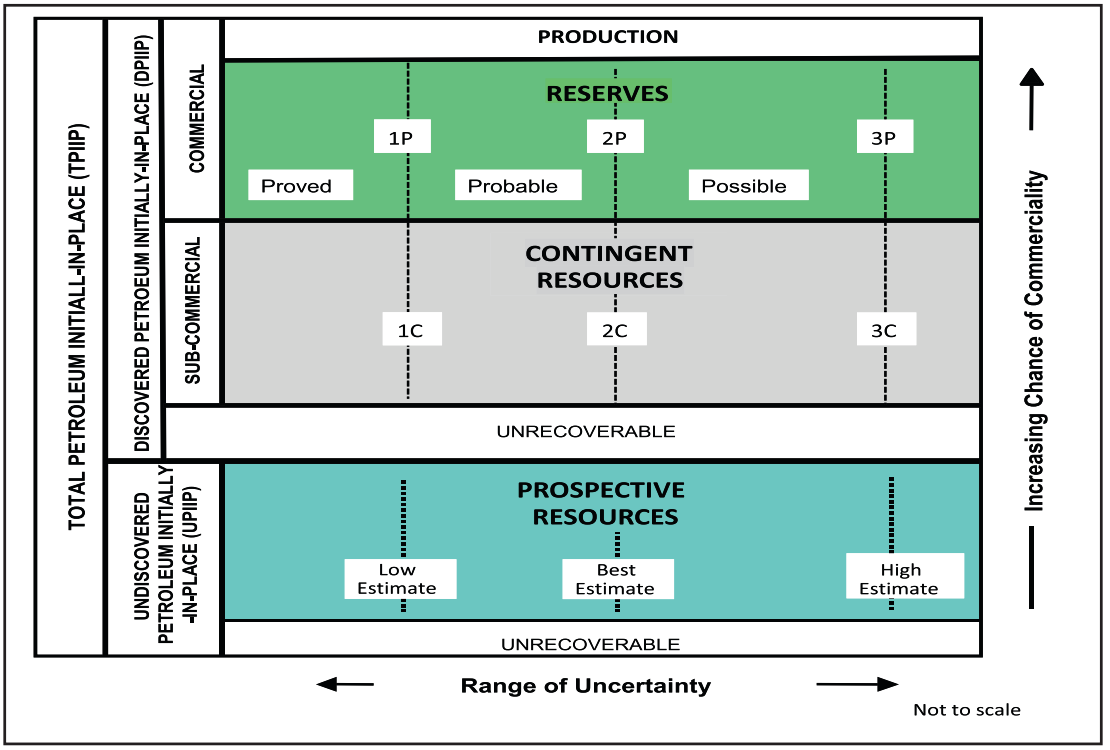

Fig. 1. The Petroleum Resource Management System (Society of Petroleum Engineers, 2007).

be identified in technical determinations of the quantity and classification of reserves exists as well as within internal due diligence reviews. Moreover, accounting standards also have something to say regarding appropriate disclosure.

The accounting standards at play for fossil fuel companies are mostly either U.S. GAAP or IFRS (Schneider, Michelon, & Maier, 2017; Schneider, 2011). An oft-held misconception is that accounting standards dictate reserves and resources reporting rules; as is apparent from the preceding description of the technical standards in play, this is not the case. Under IFRS there are no requirements for the reporting of reserves and resources. Under US GAAP it is only oil and gas firms that must disclose reserves information. Although accounting standards are largely silent on reporting reserves, they are considered a key estimate and are typically discussed in the notes to the accounts of both IFRS and US reporters. Regardless of any direct reserve reporting, reserve and resource classification and evaluation play a direct role in financial accounting issues for oil and gas and mineral firms via items such as impairment, depletion, environmental provisions (or asset retirement obligations under US GAAP) and business combinations. If a firm's reserves are re-classified as contingent resources, due to anything from a drop in the market price for fossil fuels or a carbon constraint, firms could face write-downs of their oil and gas and/or mining assets (that is, those figures on the balance sheet that reflect prior expenditure to identify reserves).

The various exchanges on which mineral and oil and gas firms are listed also have specific requirements on what reserves and resources must and may be disclosed. The most restrictive of these requirements are those of the SEC. US listed oil and gas firms must report Proved Reserves and may report other Reserves, while mining firms must report Proved plus Probable Reserves. No other disclosures are allowed. Thus, if a Reserve is re-classified as a Contingent Resource, US listed firms can no longer report them. In the other jurisdictions, resources other than reserves may be disclosed. For example, in Canada, National Instrument (NI) 51-101 (Canadian Securities Administrators, last amended 2015) dictates that proved plus probable reserves must be disclosed and other disclosure is optional (that is, possible reserves, contingent resources and prospective resources). For US reporters, future carbon constraints could move reserves off the annual reserve reports; while non-US issuers would see their reserves move to the contingent resource classification for oil and gas. Both of these have significant implications with regard to capital markets reporting.

Finally, a common element of reserves and resource disclosure in oil and gas is a discounted cash-flow valuation of the reported reserves. In the US, the Modernization of Oil and Gas Reporting (SEC, 2009) and US GAAP (FASB, 2010: Accounting Standards Codification 932 Extractive Activities – Oil and Gas) dictate a standardized measure of discounted cash-flows (often referred to as SMOG): a 10 percent discount rate and a price based on the average of previous 12 months. Meanwhile, in Canada, NI 51-101 allows for a present value (PV) disclosure based on a number of discount rates and forecast prices (the other jurisdictions also allow disclosure based on or similar to NI 51-101). Again, the key disclosure is

the classification, with the move between reserve and contingent resource being the key issue. If a resource is classified as a reserve, this implies it will provide a positive cash-flow and hence burnability. If it becomes a contingent resource, it falls out of any present value calculations.

In addition to the sector-specific reporting requirements discussed above, oil, gas and mining companies are expected to comply with more general reporting obligations (that also increasingly emphasize climate matters). For example, the US SEC issued interpretive Guidance Regarding Disclosure Related to Climate Change (2010) and it "emphasizes that disclosure of material climate change issues is a matter of *pre-existing legal obligation*, as it has long been a requirement that companies disclose material risks to investors" (Coburn, Donahue, & Jayanti, 2011, p. 9, our emphasis). Further, the Canadian Securities Administrators Staff Notice 51-333 Environmental Reporting Guidance (2010) "requires the issuer to describe any implemented environmental policies that are fundamental to its operations and the steps it has taken to implement them" (Canadian Securities Administrators, 2010, p. 16).

In summary, this outline of disclosure requirements makes several things evident. First, there is an existing set of disclosure requirements that govern fossil fuel companies' disclosures and these come from a variety of sources, only some of which are accounting orientated. Second, these disclosure requirements all have environmental parameters as part of their evaluations and provide scope for disclosures concerning the non-combustibility of reserves to be recognized[6]. Third, the professionals who are charged with responsibility for bringing this data to the public domain have environmental related duties placed on them. As a result, if carbon constraints become a contingent factor in the ability of resources to be considered commercially viable, current classification and evaluation systems dictate that this should be considered. Given this, we now explore if any disclosures of this sort have been made in recent years in our analysis for firm reporting.

4.2. Disclosure analysis

The initial cross-country sample was created in consultation with the Carbon Tracker Initiative, in a first phase of research based on disclosures in 2011: namely five of the largest listed companies with substantial fossil fuel holdings, from each of the seven countries with substantive fossil fuel listings. Documents from these 35 companies were collected for the years 2011 and 2014. Of the 35 companies, 19 were for mining, 15 were oil and/or gas and one was a combined oil, gas and coal company. In 2014, two UK companies were not in the sample due to takeovers and a South African firm had been privatized. These firms are not included in the overall 2011 versus 2014 analysis reported subsequently. All available annual reports, forms 10-K (and forms 20-F or 40-F for foreign firms listed in the United States), integrated reports, sustainability reports, and the CDP questionnaire responses (if they were in the public domain: 18 of 35 companies responded to the questionnaires in both 2011 and 2014) were included in the review. For one Australian company, the 2014 sustainability report is available online only. As our analysis required a stand-alone document, we dropped their 2011 and 2014 sustainability reports from the quantitative analysis. Appendix 2 presents the companies, by country, reviewed for this study. By taking an array of reports, and a careful selection of countries, we identified those firms who were most likely to disclose unburnable carbon, if it exists.

All documents were uploaded to the qualitative software program NVivo. Relevant passages were searched for and categorized into one of six categories. These were: (i) 'boiler plate' disclosure about risks that global climate change (and governance related to it) raises for the company; (ii) reference to greenhouse gas emissions; (iii) specific reference to 'stranded assets'; (iv) disclosures that relate to constraints on combusting carbon, (v) reference to a low carbon economy and (vi) reference to natural gas as a low carbon fuel. The search for these phrases was based on related key words (as well as their acronyms and variations): climate change (and risk), greenhouse gas, stranded assets, carbon constraints, low carbon economy, and natural gas (in the context of lower downstream emissions). The surrounding paragraphs were reviewed to assess the global climate change content in the reports. The detailed review was undertaken by one of the lead researchers, with an extensive background in the oil and gas and mining industries. Regular feedback between all researchers provided ongoing direction on the document review process. The review was methodical, with new variations of any of the key words added to the search (for example, low carbon economy also includes low emissions economy). It is possible (even probable) that the review missed certain mentions of pertinent words and phrases in forms other than those specified in the search but the process of reviewing surrounding paragraphs for relevant disclosures would have mitigated this risk. All reviews covered the companies' general climate change disclosures across all documents. Any variant not captured in the text search would need to be in unrelated sections of these documents, rather than a main message to shareholders and other key stakeholders. Although very time consuming, replication is not technically difficult, but we contend that any "counter-examples" would not affect the overall discussion and conclusions presented herein.

To give a general sense of things, Table 2 summarizes disclosures based on climate change and greenhouse gas disclosures by company, by year and by media (categories (i) and (ii) from above). In broad terms, there is a rising incidence of disclosure

[6] The Financial Stability Board's Task Force on Climate-related Financial Disclosures (2017) focuses attention on disclosing the financial implications of climate related information, in a decision-useful, consistent, comparable, context-specific way. It acknowledges existing legal obligations in developed economies to disclose material climate-related risks in financial statements but it also identifies "the absence of a standardized framework for disclosing climate-related financial risks" which impedes investor understanding.

Table 2
Disclosure summary (for all companies summed by country).

Location	Type of disclosure	2011	2014
Australia disclosures			
Annual Report	Risk Narrative	16	38
	GHG Disclosure	38	65
Form 20F	Risk Narrative	9	37
	GHG Disclosure	8	23
CSR report	Risk Narrative	33	39
	GHG Disclosure	66	60
CDP	Risk Narrative	76	143
	GHG Disclosure	68	119
Canada Disclosures			
Annual Report	Risk Narrative	11	13
	GHG Disclosure	27	25
AIF (Reserves)	Risk Narrative	14	31
	GHG Disclosure	30	52
CSR report	Risk Narrative	31	25
	GHG Disclosure	102	111
CDP	Risk Narrative	104	283
	GHG Disclosure	164	253
China disclosures			
Annual Report	Risk Narrative	1	2
	GHG Disclosure	0	0
Form 20F (two firms)	Risk Narrative	2	1
	GHG Disclosure	1	1
CSR report	Risk Narrative	6	8
	GHG Disclosure	3	5
CDP	Risk Narrative	0	0
	GHG Disclosure	0	0
Russia disclosures			
Annual Report	Risk Narrative	12	12
	GHG Disclosure	27	18
CSR report	Risk Narrative	24	22
	GHG Disclosure	37	46
CDP	Risk Narrative	19	27
	GHG Disclosure	22	24
South Africa disclosures (N.B. Integrated reports are mandated, which include the annual report)			
Integrated Report	Risk Narrative	32	24
	GHG Disclosure	32	35
Form 20F (one firm)	Risk Narrative	9	3
	GHG Disclosure	8	4
CSR report	Risk Narrative	32	43
	GHG Disclosure	38	35
CDP	Risk Narrative	91	169
	GHG Disclosure	59	106
UK disclosures			
Annual Report	Risk Narrative	27	32
	GHG Disclosure	30	40
CSR report	Risk Narrative	59	56
	GHG Disclosure	54	69
CDP	Risk Narrative	81	141
	GHG Disclosure	107	128
USA disclosures			
Form 10-K	Risk Narrative	21	19
	GHG Disclosure	33	30

Table 2 (*continued*)

Location	Type of disclosure	2011	2014
CSR report	Risk Narrative	3	37
	GHG Disclosure	33	61
CDP (two firms)	Risk Narrative	52	68
	GHG Disclosure	101	157

on risk and on greenhouse gas disclosures between the sample years and across all document-types. The incidence of disclosure does vary by country, however, with China in particular and Russia to an extent having relatively lower levels of disclosure.

The highest frequency of disclosure is found in CDP returns. This is as expected given the particular focus of the disclosure regime, but it also suggests that this investor-focused medium might be where we first see unburnable carbon disclosures in the future. Moreover, the strength of this media is that it prescribes a set of questions to which they are seeking a response (compared to 'CSR' reporting where the scope of disclosures are at the preparers' discretion). If the CDP was concerned about unburnable carbon, they might be the first to call for disclosure (we revisit this proposition in the penultimate section). While there is no inter-temporal change related to the number of firms completing the CDP questionnaire (18 of the firms responding in both years), Table 2 shows increases in the frequency of disclosures in the CDP. Exploring these specific CDP disclosures shows that the increase in disclosure is likely to have been driven by the expansion of the CDP questionnaire.

The main objective of the review was to examine the disclosures themselves, and it is here that more nuance regarding company understandings of the potential for unburnable carbon is evident. Returning to category (iii) from above, disclosures of stranded assets, BHP Billiton and Wesfarmers (both Australian companies) use this phrase in their 2014 annual reports but not in 2011. BHP's disclosure is the most forthright, starting with a sub-heading of "Stranded assets and the 'carbon bubble'", then stating:

> The potential gap between the current valuation of fossil fuel reserves on the balance sheets of companies and in global equities markets and the reduced value that could result if a significant proportion of reserves were rendered incapable of extraction in an economically viable fashion due to responses to climate change, is known as the 'carbon bubble'. Although this concept has been discussed by non-government organisations and academics for several years, there has recently been renewed interest in this topic, particularly from ratings agencies and investment analysts. There is, however, little consensus on what specific carbon prices, fossil fuel demand or market prices might trigger this devaluation[7]. Providing access to the affordable energy required to continue economic growth is essential for maintaining living standards and alleviating poverty. Under all current plausible scenarios, fossil fuels will continue to be a significant part of the energy mix for decades." BHP Billiton 2014 Annual Report, p. 51, (similar disclosures also found in its 20-F and Sustainability Report).

Given that BHP Billiton is not solely an oil and gas or coal company (neither is Wesfarmers), they may feel more comfortable commenting on unburnable carbon. At the same time, their disclosure is typical of much found in the study, offering a role for fossil fuels as underwriting living standards (with a link to alleviating poverty) and faith in a continued role of fossil fuels in general.

A total of five firms mention stranded assets (or related) in any of their reporting. Of these firms, it is only BHP Billiton and Wesfarmers who mention it in their annual reports. If management deems information to be material to investors, it must be disclosed in the annual report. Thus, by definition, all other sample firms consider the concept of stranded assets to be immaterial to their investors. The other firms that do mention stranded assets are in the 'big oil' club: BP, ExxonMobil and Shell, which emerges in 2014 in their sustainability reporting, and seems a direct response to public pressure on the issue. ExxonMobil's mention of stranded assets can be found in its 2014 Corporate Citizenship Report:

> "ExxonMobil believes producing our existing hydrocarbon reserves is essential to meeting growing global energy demand. We enable consumers — especially those in the least-developed and most-vulnerable economies — to pursue higher living standards and greater economic opportunity. We believe all economic energy sources will be necessary to meet growing demand, and the transition of the energy system to lower carbon sources will take many decades due to its enormous scale, capital intensity and complexity. As such, we believe that none of our proven hydrocarbon reserves are, or will become, stranded." ExxonMobil 2014 Corporate Citizenship Report, p. 37.

As before, there is an allusion to fossil fuels (and by extension the activities of the company) as being beneficial, especially to the developing world. What is more nuanced about this disclosure is that it refers to proved reserves only.

BP also provides assurance to its stakeholders on the value of its proved reserves via its 2014 sustainability report:

[7] While this firm was not an interviewee (see Section 3) their disclosure reflects interviewee views from the earlier time period.

"Valuations are based on proved reserves, which are not 'stranded assets'.
The value of the upstream part of BP's business is mainly based on proved reserves, and less so estimates of probable or possible reserves. BP's proved reserves are produced, and historically replaced, over a 13-year timeframe on average. On this wavelength we can adapt our investment strategy to changes in policy, market or technology conditions." BP Sustainability Report 2014, p. 16 (emphasis in original).

As Fig. 1 sought to demonstrate, proved reserves are only a sub-set of reserves and resources. On the surface these two statements imply that there is no question of stranded assets, yet technically they are focused only on a narrow definition of resources (a fact that might not be immediately apparent to a casual reader – a point also made by Ritchie & Dowlatabadi, 2015, p. 68). Although outside of the securities reporting channels, disclosures such as this (and lack of disclosure to the securities authorities) imply strongly that there is no movement to suggest to shareholders that their investment as at risk. We note here that at the time of writing, the Attorneys General of several US states have ascertained that there is inadequate disclosure in this area, with several ongoing lawsuits.[8] These investigations cover disclosures over the recent years and are likely to cover the 2014 year. Beyond this paper, our international cross-section may provide a baseline from which to continue research into how firms react to legal challenges of inadequate disclosure of material items (i.e. how do they defend themselves based on their baseline disclosures and what subsequent disclosures have they made in response?).

Considering our full cross-section of companies, with such a small number of direct references in mandatory or voluntary reports to stranded assets, we conclude that the issue of unburnable carbon is not currently considered a material item. Regardless, climate change risk is subject to more disclosure and this material has also been analysed for salience with respect to the issues addressed in this paper. In particular, several themes emerge from our analysis, including: (a) the presence in many disclosures of normative statements about the role of carbon-based fuels in the future energy mix – particularly in the sense of fossil fuels being key to economic growth and improving the lives of those in the developing world; (b) the prevalence of what we might call 'boiler plate' disclosures[9] where companies indicate that they are alert to future risks from domestic and international global climate change regulation, but that how this might crystalize is sufficiently uncertain that they cannot disclose anything material presently; and (c) a belief (not entirely unwarranted) that technological innovation will allow continued use of fossil fuels (for example, carbon capture and storage) and/or a change to the company portfolio to a heavier weighting on natural gas (as a lower carbon fuel) or renewables. In all of these instances the time frame over which change is assumed to happen is the longer term and disclosures suggest that it will be managed as it arises and/or is sufficiently uncertain that no current action is possible. These sentiments were also evident in the interviews of the previous section.

We now move to the remaining three categories described at the opening of this sub-section; categories (iv) carbon constraints, (v) low carbon economy and (vi) natural gas as a low carbon downstream fuel. It is here that we again find some echoes of the interview themes outlined in the previous section. Specifically, there is open acceptance in disclosures that change is going to come, but also that it is not happening yet. Conversely, a number of firms emphasise natural gas as a key part of the move to a low carbon economy. The firms who make these disclosures all have large natural gas reserves, with the implication that these reserves are even more valuable in a low-carbon economy. Gazprom is a clear example of a firm touting natural gas as a low carbon fuel. Gazprom owns 72% of Russian reserves[10] and it states in its 2014 annual report (referencing improved gas pipeline infrastructure):

"The project directly benefits the economic potential of virtually every Russian region and is raising the standard of living for millions of citizens. Moreover, expanding the gas supply system allows of using natural gas as the most sophisticated and clean alternative to other fuels." OAO Gazprom 2014 Annual Report, p. 68.

As a further analysis, all previously categorized mentions of natural gas were then sub-categorized into whether natural gas was described as an opportunity for the firm, or if any transition to natural gas as a lower carbon fuel was a threat to the firm. In 2011 we find 66 and in 2014 we find 65 mentions of natural gas as a low carbon fuel. All but five of these were in a positive context. Of the positive mentions, 73 percent are attributable to Gazprom (Russia), Sasol (South Africa), BP (UK) and Shell (UK), all of whom have substantial natural gas reserves.

The five negative context disclosures for natural gas are uniquely referencing the US coal industry. The disclosure by Arch Coal (US) effectively captures the sentiment:

"Additionally, coal competes with other fuels, such as natural gas, nuclear energy, hydropower, wind, solar and petroleum, for steam and electrical power generation. Costs and other factors relating to these alternative fuels, such as safety and environmental considerations, affect the overall demand for coal as a fuel." Arch Coal 2014 10-K, p. 21.

[8] For example, see an article in the Toronto Globe and Mail, October 26th, 2018 on a lawsuit by the Attorney General of New York against ExxonMobil for inadequate risk disclosure and under-estimation of future carbon costs in Alberta's oil sands: Alberta oil-sands companies likely to face lawsuits similar to Exxon: expert. Available at: https://www.theglobeandmail.com/business/article-alberta-oil-sands-companies-likely-to-face-lawsuits-similar-to-exxon/.

[9] Abdo, Mangena, Needham & Hunt (2018)also noted a tendency towards 'tick box' reporting in the context of decommissioning costs in annual reports of oil and gas companies.

[10] OAO Gazprom 2014 Annual Report, p. 10.

Arguably, natural gas is a threat to coal regardless of the climate change debate. However, having noted the prevalence of 'boiler plate' disclosures regarding climate change, there are examples of disclosure in the US coal industry that point towards what might be expected in the context of unburnable carbon (as we have seen from McGlade & Ekins, 2015, coal is likely to be more unburnable than other fossil fuels). For example, Peabody Coal (US) noted:

> "Concerns about the environmental impacts of coal combustion, including *perceived* [our emphasis] impacts on global climate issues, are resulting in increased regulation of coal combustion in many jurisdictions, unfavorable lending policies by government-backed lending institutions and development banks toward the financing of new overseas coal-fueled power plants and divestment efforts affecting the investment community, which could significantly affect demand for our products or our securities." Peabody Energy Corporation, 2014 10-K, p. 28.

In closing, Kjarstad & Jonsson (2009) observed that, if governance reflects emission reductions that accord with scientific opinion, there will be a profound impact on oil prices. The same holds for other classes of fossil fuels with the impact of price changes being translated through to individual firm valuations mediated by and reflected in stock exchanges where fossil fuel companies are listed. Some time ago, Busch and Hoffmann (2007, p. 518), after reviewing "the literature regarding the financial consequences of carbon constraints on the macroeconomic, sector and company level", found a lack of clear indication of likely capital market responses to date (p. 523, quoting Garz & Volk, 2003, see also Griffin et al., 2015). This literature suggests "most companies view climate change as a slow-burning economic risk that will happen in time frames well in excess of their investment horizons" (Leurig, 2011, p. 17). The disclosures presented here accord with this view and highlight the uncertainly about the extent of unburnable carbon while recognizing that there is evidence in some disclosures that this issue is understood. As certainty starts to emerge, the key question concerns what will trigger the existing disclosure rules to enable Miller and Power's (2013) playing out of the process of territorializing, mediating, adjudicating and subjectivizing.

5. Discussion and synthesis of the empirical work

Taking evidence from the literature review, interviews with market commentators and participants, a review of the reporting requirements for fossil fuel companies, as well as a review of disclosure practices (over time, across countries and in all corporate disclosure settings), we conclude that there is a relative absence of disclosures on unburnable carbon, despite there being a plausible case to answer with respect to combustibility. Why this might be the case requires further exploration with four themes being developed in this section. Theme one evaluates the robustness of existing mechanisms that would result in unburnable carbon disclosures. The second theme revisits the issue of whether it is possible to know specifically which carbon will be unburnable and to link that data to an economic entity. Theme three considers what we might learn from existing accounting controversies and how new accounting rules have crystalized in the past. The final, and fourth, theme proposes other sources of reporting norms that may provide information on unburnable carbon ahead of any accounting disclosure being triggered. All of these themes provide the basis for a synthesis in Section 6 of the case examined here using the Miller and Power (2013) framework.

5.1. Mechanisms for disclosure

A review of various disclosure requirements within financial reporting and stock exchange listing suggest that there is sufficient existing guidance that would lead to unburnable carbon being identified and disclosed should it be believed to exist. For example, PRMS requires assessment of what reserves are "commercially recoverable ... under defined conditions" and the Pan-European Reserves and Resources Reporting Committee's (2017) exhortation that disclosures enable users to estimate what reserves have "reasonable prospects for eventual extraction". Non-combustibility of reserves due to climate change governance fit within this guidance. Additionally, guidance about the professional duties of those certifying reserve quantities (for example, CRIRSCO's reporting template at p. 35/36) state that competent persons have an overriding duty to the public and that protecting the natural environment falls within this remit. The SEC guidance on oil and gas, and minerals, would also provide support for disclosures. There is, therefore, sufficient guidance on and specification of calculations that should be made and information that should be provided if fossil fuel reserves become unburnable. Of course, this is not a guarantee that disclosures will be made and is behind the recommendations of the Task Force on Climate-related Financial Disclosures (FSB, 2017) who seek to "help organizations meet existing disclosure obligations more effectively" (p. 17).

Central to disclosure processes are the competent persons, "professionals who take full responsibility for their submissions" (Camisani-Calzolari, 2004, p. 297). There is no suggestion that this group of professionals are not doing their job correctly, however, it would help accounting disclosure considerations if more were known about this profession and how it functions (and whether or not, for example, they have considered unburnable carbon). From the brief description offered by Camisani-Calzolari (2004), competent persons appear to have the 'usual' paraphernalia of professionals such as technical knowledge, training, certification and relevant experience (see also Njowa, Clay, & Musingwini, 2014). We have not, however, been able to find any literature to draw from to better understand this profession, nor evidence on how accountants interact with them and their evaluations (we included extensive keyword

searches of the American Institute of Professional Geologists website as well as specialist journals such as the *Journal of Professions and Organization* on these matters). This point of intersection, however, is likely to be critical to any process of translating competent persons assessments into corporate reporting (see Ascui & Lovell, 2012, for an equivalent discussion of the groups involved in carbon accounting auditing/assurance).

We, therefore, conclude that the mechanisms for identifying unburnable carbon (if it exists) are present in the existing regulatory environment and that there is no need to develop new guidance. What this finding suggests, however, is that there may be a problem translating the existing guidance into disclosure because exactly which carbon is unburnable is not clearly identified.

5.2. Identifying unburnable carbon

McGlade and Ekins' (2015) analysis demonstrates that unburnable carbon varies by geographic location and fossil fuel type. The question then arises of whether it would be possible to translate this data to the scale of an individual economic entity (this is a perennial problem for environmental accounting – see Bebbington & Larrinaga, 2014; Milne & Gray, 2013). Data on reserves by fossil fuel type in a country are found in some (but not all) country national accounts and are perceived to be of variable quality. Likewise, entity level disclosures of fossil fuels held by location are disclosed under some (but not all) corporate reporting regulations. In order to translate data from these sources a nesting of information from the international, region, country and firm level could be developed if international agencies, governments, stock markets and individual investors were to be informed about carbon constraints (this would have the additional benefit of identifying if any specific stock exchanges are differentially exposed to risk). Assembling together these data would be a non-trivial task and it may be that until this could be done, it is impossible to estimate unburnable carbon at the individual company level.

Moreover, it is also possible that climate change governance processes might specify which reserves are to stay in the lithosphere. For example, re-conceptualizing a fossil fuel reserve as a 'right' to pollute might generate a different reading of the value of a reserve. Not surprisingly, the classification systems are designed to identify resources and reserves that are valuable for as long as there is an economic use of the fossil fuels. If however, the asset is conceptualized as a pollution right that will expire at a certain time in the future (for example, when a carbon budget is 'spent') then how its value is assessed is likely to be different and may accord more closely to changes in carbon governance processes.

While it might be useful to contemplate these issues, presently there is no international governance process that would identify which particular reserves can be combusted. In a generic sense, however, it is possible to specify the data requirements for disclosure, including the domains where uncertainty would have to be resolved. Specifically, before reporting could be expected, uncertainty would have to be resolved for: (i) base physical data on reserves and resources; (ii) timing and nature of likely future global climate change governance related restrictions on combustion; (iii) the potential to offset emissions by way of technology developments (for example, carbon capture and storage); (iv) changing demand for classes of fossil fuels dictated by the approach used to transition to a low carbon economy (for example, transportation policy); (v) a sense of the location of reserves held by listed companies versus state owned companies and the effect of any differential impact on combustibility that this might bring; and (vi) the timing of the development and adoption of substitute technologies that might reduce the need for fossil fuel combustion. This list is daunting and underlines the point that (in all probability) we are in a pre-reporting phase for robust entity level estimates of unburnable carbon. The next theme considers when a crystallization point in that process could be expected.

5.3. Changing accounting practices

At critical junctures in the past, accounting has had to deal with significant changes in economic circumstances that required new accounting measurements and disclosures, the inflation accounting debate being a case in point. At the same time, there are many other occasions where accounting rules have had to adjust to more routine changes in circumstances (for example, the accounting treatment of oil and gas expenditures - see Cortese et al., 2009 – which has generated controversy). As such, some literature suggests that accounting responds to changing economic circumstances after there has been some crisis (Canning & O'Dwyer, 2013; Waymire & Basu, 2011; Zeff, 2003)[11]. Taking this point seriously, it could be anticipated that the substantive application of existing reporting guidance (as would be the case in unburnable carbon) and/or the development of new measurement and disclosure rules requires some sort of political, economic or ethical crisis. What would precipitate a crisis in the context of unburnable carbon is unclear (but the legal cases currently being launched might be a possible trigger). The economic damage that would arise for companies, stock markets and economies if large percentages of value were lost from fossil fuel stocks would be calamitous. As a result, this theme explores how a smooth(er) transition to the application of existing accounting rules that recognize a new (carbon) reality might be achieved.

[11] Discussions with senior academic researchers who examine the evolution of accounting standard setting reinforced this suggestion that change is often preceded by a crisis.

Camisani-Calzolari (2004) identifies three audiences for disclosures on fossil fuel (and other commodity) reserves, namely: international agencies, governments and investors/stock markets. Of particular interest in the context of this theme is the governmental level of resolution where codes focus on the "necessity of each state to exploit its mineral potential profitably and to secure the preservation of wealth for future generations" (p. 297). Prior failures to adequately account for reserves (for example, the Poseidon nickel boom in Australia, the Bre-X fictitious Busang gold deposit in Indonesia and the South African case of Noble Minerals – see Camisani-Calzolari, 2004, p. 301–302 for more detail and Fox, 2017) resulted in losses for the companies in question but also for national economies. In this respect there may be a strong alignment of state and market interests in accurately identifying unburnable carbon, albeit that it is unclear when and how such alignment would come to pass.

Further, and critically, global climate change responsiveness and the emergence of a carbon constraint will involve the same governments who are seeking to utilize fossil fuel reserves and resources. Jakob and Hilaire (2015, p. 151) note the:

> "distributional challenge of climate policy: imposing a limitation on the use of fossil fuels transfers economic benefits (known as rents) from resource owners to those who obtain the right to use the remaining burnable reserves. Hence, successful climate policy will crucially hinge on the question of whether this 'climate rent' can be shared in an equitable way that also ensures resource owners are compensated for these losses".

It seems, therefore, that disclosures may co-evolve with climate change governance and that understanding the distributional aspects of (for example) carbon budgets might have important implications for understanding the presence of unburnable carbon (see also Jaffe, 2016; Van de Graaf & Verbruggen, 2015, who note provisions in international climate change protocols to support energy exporting states' transition away from fossil fuels).

5.4. Parallel reporting processes

This fourth theme moves away from existing disclosure requirements to consider if there could be a non-accounting related source of unburnable carbon information. Two possible sources for the generation of data on reserves are national governments and private regulatory actors, each of which will be considered below.

Camisani-Calzolari (2004, p. 297) notes that reserves reporting codes have enabled the "spread of information across political boundaries" and highlights uranium resource classification (linked to the development of nuclear energy and weapons) as an example of international collaboration. In this case, accurate records of uranium reserves as well as the demand for them were required to allow technological development in energy markets to emerge. Given the criticality of atmospheric emissions concentrations, and the presence of national level inventories for emissions, it would be possible (with some work) to join data from the likes of McGlade and Ekins (2015) and data provided to the UNFCCC, to sketch which carbon is going to be unburnable (deciding which it would be is a complex political process as noted above). At the same time, if corporate level data were to match reserves to location and by fossil fuel type you would have the start of a mechanism to mediate between reporting and financial markets. It may be that such a process would not proceed swiftly enough to inform investors. As Van de Ploeg (2016, p. 216) suggests the "market may simply not realize that the slow policy ramp for pricing carbon on which the world seems to be, due to all kinds of national and international political obstacles, is irrational ... [and once] the correction comes, and most likely much sooner than market expect, the price of carbon will be volatile".

Leaving aside inter-governmental action, it is possible that private governance initiatives might move to offer information for markets about unburnable carbon, as has been the case in emissions reporting. Indeed, unburnable carbon might build on the World Business Council for Sustainable Development & World Resources Institute (2004) protocol. For example, this protocol distinguishes emissions by 'scope'. Existing scopes are: scope 1 (emissions from sources owned or operated by the reporting entity, for example, emissions from owned gas powered boilers); scope 2 (emissions associated with the generation of energy purchased by the reporting entity, for example, purchased grid electricity); and scope 3 (other emissions that arise as a result of the activities of the reporting entity – such as supply chain emissions). None of these scopes account for future emissions[12]. It could be argued that fossil fuels reserves and resources are an example of what could be described as 'scope 4' emissions. In particular, the review of reserves and resources reporting standards in Section 4.1 suggests that the composition and likely extraction ratios of fossil fuels reserves are known and it would be possible to convert these data into likely future emissions, should the reserve be combusted. If this calculation were undertaken, then the carbon-yet-to-be burned could be estimated. If that were the case, investors and other users of information could make their own judgements regarding risks associated with unburnable carbon in the context of known carbon budgets[13].

[12] Carbon Tracker and the UN's Principles of Responsible Investment (2017) publication *2 degrees of separation: transition risk for oil and gas in a low carbon world* uses International Energy Agency data to analyse potential carbon budgets associated with limiting global warming to 2 degrees and their distribution across global oil and gas entities.

[13] The fossil fuel industry would not be the only setting where this data could be useful. For example, it may be that those who are in charge of transport infrastructure such as air and seaports, pipelines, railways and roads might also usefully estimate this sort of information insofar as infrastructure implies the locking in of certain emissions profiles (see also Scholtens, 2017 and World Resources Institute and the United Nations Environment Programme Finance Initiative Portfolio Carbon Initiative, 2015).

This section, taken as a whole, has sought to discuss the implications arising from the empirical analysis in sections three and four. We would argue that it is a matter of when and not if a carbon constraint comes into being that will prompt further consideration of unburnable carbon. How quickly that constraint emerges and how governments, accountants, other professional groups, companies and stock markets approach this issue will be critical in terms of limiting investor losses and economic shocks. Our work has raised two issues that bear further investigation. The first concerns the nature of inter-professional engagement over reserves estimates, which might lead to better data to support investor decision-making. Second, possibilities for developing accounts of future carbon emissions linked to reserves warrants further exploration and may link to other propositions, such as being able to estimate the 'financed emissions' in loan books (another contested setting). With those specific observations made, the paper now broadens its scope to use this case to explore the functionality of accounting representations as they come into contact with alternative representations of value and explicitly reconnects this to the four functions of accounting explored by Miller and Power (2013).

6. Concluding comments

This paper sheds light on the constitutive effects of accounting through an extended study of the proposition that there is unburnable carbon on stock exchanges. Central to this paper is a belief that here is a mismatch between the value that investors ascribe to future fossil fuel reserves and resources and an ecological reading of the future (informed by science and policy). This mismatch is important if we accept that "accounting defines as well as mediates interests" (Willmott et al., 1992, p. 33). Our working hypothesis was that the science view of combustibility of fossil fuels is the 'better' value judgement and there is evidence from the literature, some disclosures and interviews that if the science view is sustained, fossil fuel company values will be reduced. The relative lack of disclosure and non-recognition of unburnable carbon by stock markets, therefore, required an explanation.

In the context of fossil fuel reserves and resources reporting, well-established practices of translation exist that enable geologically informed representations of quantities and qualities of reserves and resources to have value relevance for firms, with such data being found in financial reporting artefacts (annual reports). It would appear that the "procedures of measurement, classification and recording that can be applied to a domain of activities" (Robson, 1991, p. 551) have been satisfied in this case. Emerging from the global climate change governance process, however, are contradictory judgements regarding the value of reserves and resources. That is, it has been recognized in both policy and economic literatures (as well as by our study participants) that some fossil fuels will not be combusted given the demands for climate stability. Given the centrality of accounting technology (which we regard to include information reporting in annual reports that have value relevance), Miller and Power's (2013) typology of accounting's functionality provides a way of explaining why unburnable carbon is currently not recognized in company reporting.

The first function Miller and Power (2013) identify is that accounting creates (and recreates) calculative spaces for organizational and societal actors to interact (***territorializing***). In the context of climate change governance, a desire to limit greenhouse gas emissions is translated into a physical quantity of emissions that can be emitted (the carbon budget) without breaching what science (as modified by the political process) determines is appropriate in order to avoid dangerous climate change. At the same time, another calculative practice (that of fossil fuel reserves and resource reporting) creates a measure of the value of fossil fuels without (currently) strong reference to the climate change informed set of calculations. This is not to say that translation, in a technical sense, is impossible between these different calculations. Indeed, McGlade and Ekins (2015) achieve this by translating fossil fuel reserves into emissions along with estimations of the proportion that are unburnable on a regional basis. This suggests that territorialisation is at least partially possible. Further, these calculations create, in principle, a space where interactions might occur and where the difference in societal and capital market views of the value of fossil fuel reserves could be discussed (mediation)[14].

Moving to Miller and Power's (2013) second function (***mediation***), some complications can be observed. Mediation implies that actors can interact with each other because territorialisation has taken place. The actors that we might identify in this context are those dealing with stock market valuations and those considering carbon constraints. There are some communicative domains where these groups interact, with the CDP and standalone reports providing potential points of connection. Given neither of these reporting formats are yet fully engaged with unburnable carbon, possibilities for mediation on that specific aspect is possible in theory but not yet achieved in practice. It is also the case that fossil fuel reserves and resources reporting itself takes place within a corporate reporting mechanism (the Annual Reports and Accounts) that is less amenable to the inclusion of environmental considerations, and as such while a company may produce accounts that could be seen to create an economic-environmental hybrid (the standalone report) these are not fully integrated within the firm itself. Moreover, the notion of a carbon budget (which would bring unburnable carbon more clearly into the frame) is not one that is used within any of the reporting media examined, whose focus is historical (rather than prospective as would be encapsulated in the idea of scope-4 emissions).

Third, and moving to ***adjudication***, several points can be made. First, we have suggested above that both territorializing and mediating functions are only partially achieved in the case presented and this, in a general sense, makes evaluation of

[14] Carbon Tracker Initiative and Principles for Responsible Investment (2017) allocate carbon budgets under a 2 degree scenario to largest 69 publicly traded oil and gas companies but a lack of observable response to this work suggests that territorialization has not yet occurred.

activities of organizations' performance in the context of unburnable carbon difficult to achieve. At the same time, and critically, our interviews suggested that while market participants acknowledged the salience of the idea of unburnable carbon, they were unable to identify what particular carbon might be left unburnt. This is due to an underlying lack of certainty of when and how any carbon constraint would arise as well as a lack of knowledge of possible technological innovations (such as carbon capture and storage) that may alter current beliefs as to what carbon is non-combustible. The impossibility of linking McGlade and Ekin's (2015) data to particular corporate contexts (that is, a less than full territorializing) means that adjudication is also impaired. Having noted that, a less than full adjudication does not mean that there is none taking place at all. In particular, there is evidence of fossil fuel divestment prompted by concerns about carbon constraints. This implies that over time we may see this element of Miller and Power's (2013) framework strengthen – especially if territorializing and mediating functions also become more robust.

Fourth, and finally, control (***subjectivizing***) has not yet been observed in the case of unburnable carbon and fossil fuel reserves and resources reporting (at least in part due to the flow through nature of weaknesses in the preceding elements: territorializing, mediating and adjudicating). In addition, there are different degrees of legitimacy (and hence narrative power) associated with the positions held by market participants versus climate change governance actors with corporate narratives of value being more powerful presently. At the same time, there are hints that corporate power can respond to development-orientated concerns when a link is made in disclosures from fossil fuels to developing world well-being. Ultimately, establishing control over global climate change futures by way of identifying which carbon can be burned (implied in a carbon budget) is the key to recognition in the reports on reserves and resources held by fossil fuel companies.

To close, we argue that the case of unburnable carbon illuminates the processes by which accounting gains salience as well as the "spatially and historically varying calculative practices ... that allow accountants and others to describe and act on entities, processes and persons" (Chapman et al., 2009, p. 1). Indeed, our work demonstrates that reporting of fossil fuel reserves and resources (as a part of the broader accounting assemblage) is "engaged in a dual hybridisation process, seeking to make visible and calculable the hybrids that it encounters, while at the same time hybridising itself through encounters with a range of other disciplines" (Miller, Kurunmäki, & O'Leary, 2008, p. 942). The Miller and Power (2013) characterisation of the various ways in which accounting functions has enabled us to address the aim of this paper: to explain why contrasting accounts of the value of fossil fuel reserves co-exist. The framework, however, also enabled us to suggest how this situation could change and that processes would be required in order for the value ascribed to fossil fuels to be established in a way that reflects both economic and ecological rationales. In a modest way, this paper also provides an insight into the value of the Miller and Power (2013) framework for understanding accounting. In that respect, their typology was helpful to deconstruct a contemporary setting where accounting and reporting practices have yet to emerge.

Acknowledgements

The authors would like to thank the Association of Chartered Certified Accountants and the Carbon Tracker for sponsoring aspects of this work. Thanks are also due to Nicola Brown for undertaking report analysis and Ling Wang for analysis of company reports in Chinese. Thanks are also due to Sonia Khao, Rachel Jackson, James Leaton, Kyle Stevens-Cox and the interviewees who gave freely of their time for this project. Comments and questions from participants at workshops and conferences where earlier versions of this paper were presented and the most helpful conversations with Vivien Beattie, Robert Charnock, Mary Canning, Delphine Gibassier, Martina Lunnenlueck, and Bert Scholtens are also acknowledged as are the comments of journal reviewers of the paper and Markus Milne's valuable input.

Appendix

Appendix 1
Selected resource evaluation, classification and disclosure codes and regulations (for countries subject to analysis).

Country	Minerals	Oil and Gas
International	Committee for Mineral Reserves International Reporting Standards (CRIRSCO) – International reporting template (2013)	Petroleum Resource Management System (PRMS)
	United Nations Framework Classification for Resources 2009 (see United Nations Economic Commission for Europe, 2015)	United Nations Framework Classification for Resources (2009)
Australia	ASX Listing Rules Chapter 5: Additional Reporting on Mining and Oil and Gas Production and Exploration Activities Evaluation and Classification is based on the Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves (Joint Ore Reserves Committee, hereafter JORC, 2004), one of the CRIRSCO family of codes	ASX Listing Rules Chapter 5: Additional Reporting on Mining and Oil and Gas Production and Exploration Activities ASX Listing Rules Guidance Note 32: Reporting on Oil and Gas Activities

Appendix 1 (*continued*)

Country	Minerals	Oil and Gas
		Proved plus Probable Reserves must be disclosed all other Resources may be disclosed Classification and evaluation must be based on PRMS
Canada	Canadian Securities Administrators National Instrument 43-101: Standards of Disclosure for Mineral Projects Evaluation and Classification is based on the Canadian Institute of Mining: Definition Standards on Mineral Resources and Mineral Reserves (CIM, 2005), one of the CRIRSCO family of codes and standards	Canadian Securities Administrators National Instrument 51-101: Standards of Disclosure for Oil and Gas Projects Proved plus Probable Reserves must be disclosed; all other resource classifications may be disclosed
		Evaluation and Classification is based on the Canadian Oil and Gas Evaluation Handbook (COGEH)
China	China has its own national system. Securities regulations differ by exchange Hong Kong dictates JORC, NI 43-101, SAMREC, or other code acceptable to the Exchange	China has its own national system. Securities regulations differ by exchange Hong Kong dictates PRMS, or other code acceptable to the Exchange (i.e. COGEH)
Russia	The (Russian) National Association for Mineral Resources (NAEN, 2011) Part of the CRIRSCO family of codes and standards	Oil and Fuel Gas Reserves and Resources Classification of the Russian Federation of 2013
South Africa	The South African Code for the Reporting of Exploration Results, Mineral Resources and Mineral Reserves (SAMREC, 2007) Part of the CRIRSCO family of codes and standards	The South African Code for the Reporting of Oil and Gas Resources (SAMOG) 2015 Edition, as amended 1st February 2015 The South Africa Regulator has developed a working relationship with the Alberta Securities Commission and models its regulation directly after the Canadian regulation NI 51-101 (required disclosure of P1 + P2 reserves, P3 and resources optional)
UK*	Commission Regulation (EC) 809/2004, as updated 20 March 2013 Classification and evaluation is allowed based on any of the CRIRSCO family of codes and standards	Commission Regulation (EC) 809/2004, as updated 20 March 2013 Classification and evaluation is allowed based on PRMS, COGEH or the Norwegian Petroleum Directorate
USA	SEC Industry Guide 7 (1981)	Modernization of Oil and Gas Reporting (2008). This provides revisions to Regulations S-K and S-X, allowing for the first time, the reporting of Probable Reserves
	Only proved plus probable reserves are allowed to be disclosed. The classification and evaluation methods are given in the guide, but are fairly vague and no national guidelines are cited	Proved Reserves must be reported, Probable Reserves may be reported, no other Reserves or Resources may be reported in required filings *Accounting Standards Codification*™ Topic 932 – *Extractive Activities* requires note disclosure of Proven Reserves

* There is also a specific '*Note for Mining and oil and gas companies*' for listing on the Alternative Investment Market (AIM) which was issued in June 2009.

Appendix 2
List of companies reviewed.

Russia	Canada	South Africa	China
Severstal JSC	Teck Resources Ltd*	Exxaro Resources Ltd*	Shanxi Coking Co Ltd
Mechel OAO	TransAlta Corp*	Sasol Ltd*	Inner Mongolia Yitai Coal Co. Ltd
Rosneft Oil Co.	Canadian Natural Resources Ltd*	African Rainbow Minerals Ltd*	China Shenhua Energy Co. Ltd
Lukoil Holdings	Suncor Energy Inc*	Optimum Coal Holdings Ltd**	SINOPEC Ltd
Gazprom OAO*	Husky Energy Inc*	Wescoal Holdings Ltd	CNOOC Ltd
USA	**UK**	**Australia**	
Peabody Energy Corp	Eurasian Natural** Resources Corp plc	Rio Tinto*	
Alpha Natural Resources Ltd	Xstrata plc**	BHP Billiton*	
Arch Coal Inc	Anglo American plc*	Wesfarmers Ltd*	
Exxon Mobil Corp*	BP plc*	Oil Search Ltd	
Chevron Corp*	Royal Dutch Shell plc*	Woodside Petroleum Ltd*	

* Responds to 2011 and 2014 CDP Questionnaires.
** Taken over or privatized between 2011 and 2014.

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